Strategic Plan for The Cosmic Frontier (2009-2011)

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Mission

The mission of the CD Experimental Astrophysics program is to explore the cosmic frontier.

The Experimental Astrophysics program enables Fermilab to collaborate with universities and other institutions internationally in projects that are aligned with the mission of the laboratory, that are at the forefront of research in their particular field, and for which the laboratory can contribute unique benefit.

Additionally, some members of the Computing Division participate in experimental astrophysics projects that are led by other parts of the Laboratory.

Context and Assessment of Current State

The program is primarily centered on the Experimental Astrophysics Group (EAG), but includes participants from several other departments throughout the division. The program operates under the umbrella of the Center for Particle Astrophysics (FCPA), which oversees the overall program within the Laboratory. The Dark Energy Survey (DES) and its two major components - the camera project (DECAM) and Data Management, are in the construction phase. The NASA/DOE Joint Dark Energy Mission, which supercedes the SuperNova Acceleration Probe (SNAP), is being reviewed as part of the Astro2010 Decadal Survey. The Auger project is nearing completion of construction and is in full operation. The Cold Dark Matter Search (CDMS) is in operations at Soudan. COUPP are just beginning underground operation of a rebuild of their current chamber which is now 4 kg, and are engaged in the system commissioning of a 60 kg chamber which will begin underground operation at Fermilab when commissioning is successfully completed. The Computational Cosmology Initiative (CCI), being led by the Theoretical Astropysics Group in PPD but will involvement of CD members, is producing its first results. The 21 cm BAO dark energy project is is in an intense phase of feasibility studies and R&D. The Holometer project, which seeks to detect Planck scale effects, is approaching the proposal stage. The Sloan Digital Sky Survey (SDSS) has completed construction of the long-term archive.

Vision

The vision for the Dark Energy Survey (DES) is to deliver a working instrument and operations systems so it can deliver fundamental new science in the first year of operations. Since the character of the NASA/DOE Joint Dark Energy Mission (JDEM), (which has superceded SNAP) has changed in the past year, the vision is to maintain a minimal but still critical mass of effort in anticipation of an Announcement of Opportunity in order to ensure that Fermilab will be in a position to lead a science proposal and to have an opportunity to host the mission's Science Operations Center. The vision for the Auger project is to confirm and understand the apparent anisotropy signal, which will have a seminal impact on the field of cosmic ray physics. The vision for CDMS is either to detect or provide the world's best upper limits to the detection of

Dark Matter. COUPP is advancing the sensitivity frontier in the search for the direct detection of Dark Matter using heavy liquid, room temperature, bubble chambers as nuclear recoil detectors for the observation of dark matter scattering. They hope to either detect or else achieve the best cross-section limits for both spin dependent and spin independent dark matter-nucleus scattering. The vision for the Holometer project is to develop the scientific case and technical capabilities needed for the experiment so it can be executed in three years. The vision for the 21 cm BAO project is tentative, since it involves an international collaboration and will be large funded by external sources. The vision for the SDSS is to maintain the data archive and mine it for new science results for the next 5 years. The vision for the Cosmological Computing Initiative is that it deliver simulations of use to DES in three years. The vision for any future projects, such as the Large Synoptic Survey Telescope (LSST) is to maintain contact with the projects and people leading them.

While the core size of EAG is expected to remain stable, it is expected that the Experimental Astrophysics program will continue to attract collaborators from other experiments within the laboratory as the makeup of the laboratory's program changes in the next several years. The Fermilab Long Range Plan envisions growth in the overall astrophysics program of a factor of 3 over its current size in the next 5 to 10 years.

Stakeholders

The stakeholders for each project consist of: 1) the funding agencies; 2) collaborators both within and external to Fermilab; and 3) the public scientific community at large. Unlike traditional particle physics experiments, data from particle astrophysics experiments often have legacy value and utility to researchers outside the experiment.

Goals and Objectives

1. Dark Energy Survey:
    - DECAM: Work with DES collaboration to deliver DECAM to CTIO and to conduct survey planning and mock data challenges to prepare for start of survey operations by 2011. Delivery of DECam includes participating in installation and commissioning and ongoing technical support of Fermilab deliverables.
    - DESDM: Provide a secondary DES archive node containing a full copy of the raw and processed data. Participate in development of the co-addition pipeline. Set up a copy of the DESDM processing pipeline at Fermilab to understand how we would help with seasonal reprocessing.
    - Participate in DES operations.
2. JDEM: Work with the members of the original SNAP collaboration to develop a winning dark energy proposal for the NASA/DOE Joint Dark Energy Mission in response to an anticipated Announcement of Opportunity expected sometime in calendar year 2010. Develop a prototype of the Science Operations Center, leading to preparation of a compelling proposal.
3. CDMS: Work with the CDMS group in PPD to ensure that data are acquired and processed in a timely fashion.
4. COUPP: Commission and operate the 60 kg chamber underground at Fermilab until acceptable operation and background rates are achieved. Once these goals

are achieved the plan is to move this chamber deep underground at SNOLAB (~late 2010). The potential improvement of the dark matter limits is a factor of >1000 beyond those of the COUPP 2008 Science publication.

5. AUGER: Work with the Auger group in PPD to ensure that data are processed in a timely fashion while also developing the science case for Auger North. Analyze data to monitor stability of instrument subsystems, and propose for new hardware and/or software tests as necessary.
6. Holometer: Work with member of PPD and external collaborators to design and construct the experiment and operate.
7. 21 cm BAO: Work with the collaboration to prepare a design report, build the collaboration, and develop a proposal for a10% prototype.
8. Computational Cosmology Initiative: Ensure that CCI simulations meet the requirements for analysis of DES and JDEM data and are competitive with the best simulations in the world.
9. Ensure that SDSS archive continues to operate for the benefit of Fermilab scientists, the SDSS collaboration, and the scientific community and general public.
10. FUTURE: Identify and develop new opportunities in Experimental Particle Astrophysics. [See http://astro.fnal.gov/Retreat/Retreat0409/index.html and http://astro.fnal.gov/Retreat/Retreat0609/index.html.]

Strategies

The broad strategies to achieve the strategic goals are:
1) provide a productive working environment for astronomical data collection and analysis;
2) utilize shared resources within the Computing Division, especially those developed for larger physics experiments, where possible, to maximize efficiency;
3) leverage the Computing Division and EAG's expertise in conducting large, data-intensive surveys, by applying common knowledge and solutions to similar areas in different projects;
4) collaborate with colleagues from affiliated project institutions.

Resource Needs

At present EAG has12 members (including postdocs) - 10 scientists and 2 computational physicists. Three scientists in other departments in CD participate at least part-time. Additionally, the particle astrophysics projects draw on computing professionals, engineers, and technician in other departments in CD and with scientists and personnel in other divisions. Through the FCPA, the particle astrophysics projects work closely with scientists in other divisions and numerous visitors. To maximize the effectiveness of these people, space within the FCPA is required to accommodate them.

Progress Indicators

For DES, the major progress indicators are passing DOE reviews and meeting the various project milestones, particularly those related to data challenges.
For JDEM, progress is defined by achieving internal project milestones, working towards the delivery of science and SOC proposals.

For CDMS, progress is defined by data release publications, with analysis.
For COUPP, fundamental progress in this science is controlled by the rate of un-controlled backgrounds measured in events per kilogram per day. This translates into published cross-section upper limits every year or two. The migration of chambers to lower depths: e.g. the 60 kg from commissioning to underground at Fermilab to SNOLAB are also milestones.
For AUGER, progress is defined by data release publications, with analysis.
For CCI, progress is defined by the size (volume of universe), detail (number of particles) and accuracy (physics) of the simulations.
For the Holometer, progress will be measured by submission, approval and successful funding of the proposal.

Additional Information

From time to time, opportunities arise to broaden the Particle Astrophysics and the Computing Division's participation in these projects in areas where the Computing Division has significant strengths.